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Declaration under Rule 4.17:

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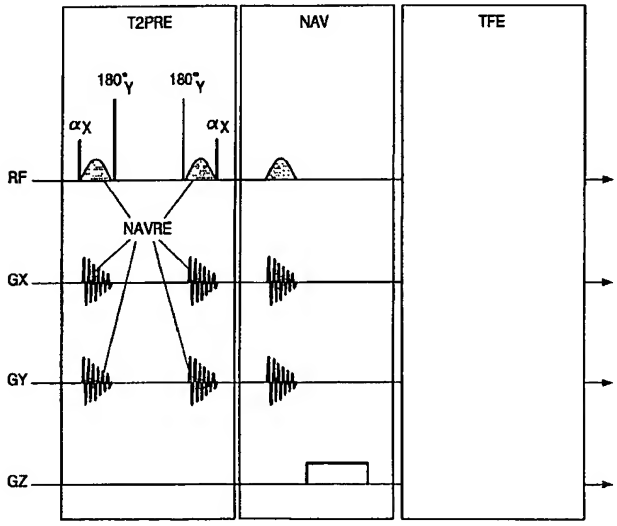
(54) Title: MAGNETIC RESONANCE METHOD AND DEVICE



(57) Abstract: The invention relates to a method for magnetic resonance imaging (MRI) of at least a portion of a body placed in a stationary and substantially homogeneous main magnetic field. According to this method, the portion of the body is initially subjected to a T_2-preparation sequence (T2PRE). Thereafter, a 2D navigator sequence (NAV) is applied and an MR navigator signal is measured. A series of MR imaging signals is subsequently generated by an imaging sequence (TFE). These MR imaging signals are measured for reconstructing an MR image therefrom. In order to provide a MRI method for T_2-weighted imaging, which gives a high T_2 contrast and also guarantees a faultless functioning of the navigator, the invention proposes to apply a 2D navigator restore sequence (NAVRE) prior to irradiation of the 2D navigator sequence (NAV).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Magnetic resonance method and device

The invention relates to a method for magnetic resonance imaging of at least a portion of a body placed in a stationary and substantially homogeneous main magnetic field, the method comprising the following steps:

a) subjecting said portion to a T_2-preparation sequence;

b) further subjecting said portion to a 2D navigator sequence;

c) measuring a MR navigator signal;

d) generating a series of MR imaging signals by subjecting said portion to an imaging sequence;

e) measuring said MR imaging signals for reconstructing an MR image from said signals.

Furthermore, the invention relates to a device for magnetic resonance imaging for carrying out this method.

In magnetic resonance imaging (MRI), pulse sequences consisting of RF and magnetic field gradient pulses are applied to an object (a patient) to generate magnetic resonance signals, which are scanned in order to obtain information therefrom and to reconstruct images of the object. Since its initial development, the number of clinical relevant fields of application of MRI has grown enormously. MRI can be applied to almost every part of the body, and it can be used to obtain information about a number of important functions of the human body. The pulse sequence which is applied during a MRI scan determines completely the characteristics of the reconstructed images, such as location and orientation in the object, dimensions, resolution, signal-to-noise ratio, contrast, sensitivity for movements, etcetera. An operator of a MRI device has to choose the appropriate sequence and has to adjust and optimize its parameters for the respective application.

Known methods of the type specified above can be employed for magnetic resonance angiography (MRA), particularly for coronary MRA.

T_2-weighted imaging sequences are used in general clinical application because they provide exquisite soft tissue contrast. Known imaging methods consist of an initial contrast preparation period, during which the longitudinal magnetization is prepared according to the desired contrast. Such a T_2-preparation sequence enables the production of

T_2-weighted images. This is particularly useful in coronary MRA, because an enhanced contrast between the blood in the coronary arteries and the myocardium is obtained (so called bright-blood methods).

Because respiratory motion of the heart can severely deteriorate the image quality of cardiac MR imaging, gating and image correction based on MR navigator signals was introduced to reduce these artifacts. By means of such MR navigator signals, the position of the diaphragm can be monitored and used as an input for an appropriate gating algorithm. Furthermore, the information of the navigator signal may be used to perform motion correction to improve image quality.

For registering the MR navigator signals, so-called 2D RF pulses may be used. These excite a spatially restricted volume, for example of pencil beam shape, which is read out using a gradient echo. This allows to monitor motions of the examined portion of the body along one direction. In coronary MRA, the navigator volume is usually localized at the dome of the right hemidiaphragm such that the motion of the diaphragm can be observed by the image contrast between the liver and the lung.

The above-mentioned 2D RF pulses consist of shaped RF pulses which are irradiated in combination with fast magnetic field gradient switching. It has been shown, that this technique facilitates the excitation of arbitrarily shaped profiles in two dimensions.

Subsequent to the T_2-preparation and the measurement of the MR navigator signals, usually a series of phase-encoded spin echoes is generated by an appropriate imaging sequence of RF pulses and magnetic field gradient pulses. These spin echoes are measured as MR imaging signals for reconstructing an MR image therefrom, for example by 2D Fourier transformation.

A T_2-contrast enhanced MRA procedure of the type specified above is for example described in a publication by Botnar (R.M. Botnar et al., „A Fast 3D Approach for Coronary MRA“, Journal of Magnetic Resonance Imaging, volume 10, pages 821-825, 1999). According to this known method, at first a T_2-preparation sequence is applied in order to obtain the desired contrast between blood and muscle. Thereafter, the patient is subjected to a so-called regional saturation pulse for suppression of signal contributions from the chest wall. The next step is the application of the 2D navigator sequence and the measurement of the MR navigator signal. According to the above article, then a spectral saturation inversion recovery sequence in employed for fat suppression prior to the actual imaging sequence, which is a so-called 3D TFE-EPI sequence.

With this known method, it is advantageous that the navigator signal comes immediately before the imaging sequence. It has been shown by Spuentrup (Spuentrup et al., „The Impact of Navigator Timing Parameters and Navigator Spatial Resolution on 3D Coronary Magnetic Resonance Angiography", Journal of Magnetic Resonance Imaging, volume 14, pages 311-318, 2001) that it is crucial to minimize the delay between the navigator and the imaging sequence. But one of the main drawbacks of the known method is that the initial T_2-preparation disturbes the generation and registration of the MR navigator signal. This is because the longitudinal magnetization of the lung-liver interface, which is used to monitor the position of the diaphragm during the respiratory motion of the patient, is substantially reduced due to the preceding T_2-preparation sequence. As a result, the navigator may fail to detect the diaphragmatic position such that a diagnostic image of sufficient quality can not be generated. This is particularly valid if, depending on the position of the navigator, structures within the liver such as the gall bladder, which has a long T_2, produce bright navigator signals. These signals might easily be misinterpreted by the involved algorithms.

Therefore, it is readily appreciated that there is a need for an MRI method which enables T_2-contrast enhanced imaging without limiting the quality of the MR navigator signal. It is consequently the primary object of the present invention to provide a method for T_2-weighted imaging, which gives a high T_2 contrast and also guarantees a faultless functioning of the navigator.

In accordance with the present invention, a method for magnetic resonance imaging of the type specified above is disclosed, wherein the aforementioned object is achieved by subjecting the portion of the body to a 2D navigator restore sequence prior to subjecting the portion to the 2D navigator sequence in step b).

The present invention enables to perform fast tomographic scanning with enhanced T_2 contrast. While the method of the invention is particularly valuable for MRA, it can also be applied to any navigator based imaging technique. The structure of the imaging procedure is similar to the above-described known method. But the essential difference is the application of the 2D navigator restore sequence, which is generated prior to the actual 2D navigator sequence. The 2D navigator restore sequence of the invention comprises RF pulses and magnetic field gradient pulses, which are selected such that the effect the T_2-preparation sequence has on the MR navigator signal is largely compensated for. This compensation can effectively be performed, because with the 2D navigator restore sequence it is possible to

selectively manipulate nuclear magnetization in the particular restricted volume, which is subsequently sampled by the 2D navigator sequence in the above-described known fashion.

The application of a 2D navigator restore sequence is known in a different context from a publication by Stuber (M. Stuber et al., „Three-Dimensional High-Resolution Fast Spin-Echo Coronary Magnetic Resonance Angiography", Magnetic Resonance in Medicine, volume 45, pages 206-211, 2001). But in contrast to the present invention, this known publication is dealing with the so-calles black blood technique, in which an initial RF pulse for non-selective inversion of the nuclear magnetization is followed by a selective inversion pulse for re-inversion of the magnetization. After the initial pulse, there is an inversion delay to facilitate signal-nulling of the in-flowing blood at the region of interest. According to the above publication, a 2D navigator restore sequence is implemented, which locally reinverts (i.e. restores) the longitudinal magnetization at the position of the navigator. This known method does obviously not enable T_2-weighted imaging with a high T_2 contrast and with a well-functioning navigator, as it is the object of the present invention.

With the method of the present invention it is practical if the T_2-preparation sequence comprises at least two RF pulses, which are separated by a relaxation period, for enhancing the contrast between tissues with different transverse relaxation times. With the initial RF-pulse, which is preferably a 90° pulse, the equillibrium magnetization is transformed into transverse magnetization. Only magnetization of tissue with a long T_2 will survive the subsequent relaxation period. After the relaxation period, the remaining transverse magnetization is transformed back into longitudinal magnetization by the so-called „tip-up" RF pulse of the T_2-preparation sequence, which again preferably has a flip angle of 90°. It is also possible that the T_2-preparation sequence further comprises an even number of substantially 180° RF pulses, thereby avoiding preliminary loss of transverse magnetization because of local inhomogeneities of the main magnetic field.

A 2D navigator sequence, which comprises at least two shaped RF pulses and at least one gradient pulse being switched during irradiation of said shaped RF pulse, is well suited for application according to the method of the invention in order to enable the excitation of nuclear magnetization within a spatially restricted navigator volume. In this way, the 2D navigator restore sequence can be applied during the relaxation period of the T_2-preparation sequence for selectively transforming transverse magnetization within the navigator volume into longitudinal magnetization. This procedures enables the simultaneous application of the T_2-preparation sequence and the 2D navigator sequence, which is particularly advantageous regarding the speed of the imaging procedure. No additional time

is needed for the 2D navigator restore sequence by integrating it into the T_2-preparation sequence. In practice, the transverse magnetization, which is generated by the initial RF pulse of the T_2-preparation sequence, is immediately transformed back into longitudinal magnetization by the 2D navigator restore sequence. At the end of the relaxation period, this longitudinal magnetization is again transformed into transverse magnetization such that it can be restored into longitudinal magnetization by the non-selective tip-up pulse of the T_2-preparation sequence.

In practice, the MR navigator signal of the present invention can advantageously be employed for gating of the imaging sequence and/or for adjusting the parameters of said imaging sequence and/or for correction of said MR image. Regarding the image quality, good results are obtained if both gating and adaptive motion correction of the imaged volume (so-called slice-tracking) are performed.

In terms of imaging speed, it is particularly useful if the imaging sequence of the method of the invention is a turbo field echo (TFE) sequence. It turns out in practice that good results are obtained with a 3D TFE-EPI sequence with partial k-space acquisition.

It is easily possible to incorporate the method of the present invention in a dedicated device for magnetic resonance imaging of a body placed in a stationary and substantially homogeneous main magnetic field. Such a MRI scanner comprises means for establishing the main magnetic field, means for generating gradient magnetic fields superimposed upon the main magnetic field, means for radiating RF pulses towards the body, control means for controlling the generation of the gradient magnetic fields and the RF pulses, means for receiving and sampling magnetic resonance signals generated by sequences of RF pulses and switched gradient magnetic fields, and reconstruction means for forming an image from said signal samples. In accordance with the invention, the control means, which is usually a microcomputer with a memory and a program control, comprises a programming with a description of an imaging procedure according to the above-described method of the invention. For ECG-gating of the imaging procedure, ECG-means may be provided for registering ECG-data from the body of the patient. These ECG-data may be processed by the control means of the MRI scanner.

The invention further relates to a computer programme as defined in Claim 10. When loaded in the computer of the MR-system enables the MR-system to perform the method of the invention. The computer programme according to the invention enables the magnetic resonance imaging system to achieve the technical effects involved in performing the magnetic resonance imaging method of the invention. The computer programme is loaded

in the computer of micro-processor of the magnetic resonance imaging system. The computer programme of the invention may be provided on a data carrier such as a CD-ROM or may be made available via a data network, such as the world-wide web.

The following drawings disclose preferred embodiments of the present invention. It should be understood, however, that the drawings are designed for the purpose of illustration only and not as a definition of the limits of the invention.

In the drawings

Fig. 1 shows a diagram of a pulse sequence in accordance with the present invention;

Fig. 2 shows an embodiment of a MRI scanner according to the invention.

A sequence design in accordance with the method of the present invention is depicted in Fig.1. The diagram shows the temporal succession of radio frequency pulses RF and of magnetic field gradient pulses GX, GY, GZ in three orthogonal directions. A patient placed in a stationary and substantially homogeneous main magnetic field is subjected to these pulses during the MRI procedure of the invention.

The sequence begins with a T_2-preparation sequence T2PRE comprising two non-selective RF pulses α_X, which are separated by a relaxation period. Only nuclear magnetization of tissue with a long T_2 will survive the relaxation period of the sequence T2PRE. This magnetization is transformed into longitudinal magnetization with the second α_X pulse. The T_2-preparation sequence T2PRE further comprises two $180°_Y$ RF pulses in order to avoid preliminary loss of transverse magnetization because of local inhomogeneities of the main magnetic field.

As further shown in Fig.1, a 2D navigator sequence NAV is applied after the sequence T2PRE. The sequence NAV comprises a 2D pulse consisting of a shaped RF pulse, during which gradients GX and GY are switched rapidly. A restricted two-dimensional spatial profile, as for example a pencil beam shaped navigator volume at the dome of the right diaphragm of the patient, is excited by these pulses. At the end of the 2D navigator sequence NAV a MR navigator signal is measured in the presence of a gradient GZ, thereby enabling the reconstruction of a one-dimensional image of the navigator volume. This image can be used to monitor the position of the patient's diaphragm during respiration.

A series of MR imaging signals is generated by subjecting the patient to a turbo field echo sequence TFE. These signals are measured and used for reconstruction of an diagnostic MR image, for example of the coronary arteries of the patient. The navigator signals, which had been measured during the sequence NAV, are used for gating of the imaging sequence TFE and for correction of the reconstructed MR image.

In accordance with the invention, a 2D navigator restore sequence NAVRE is applied prior to the 2D navigator sequence NAV. In Fig.1, the sequence NAVRE is incorporated into the sequence T2PRE in order not to loose any time with the application of additional pulses. The 2D navigator restore sequence NAVRE comprises a first 2D pulse, which is irradiated immediately after the first α_X pulse, thereby selectively transforming the transverse magnetization of the navigator volume, which was generated by the initial RF pulse α_X, back into longitudinal magnetization. This longitudinal magnetization is not affected by transverse relaxation during the relaxation period. A second 2D pulse of the sequence NAVRE is applied just before the second α_X pulse. The longitudinal magnetization of the navigator volume is again transformed into transverse magnetization such that it is restored into longitudinal magnetization by the second „tip-up" α_X pulse of the T_2-preparation sequence T2PRE. As a result, the nuclear magnetization of the navigator volume is virtually not disturbed by the T_2-contrast enhancing sequence T2PRE.

In Fig.2 a magnetic resonance imaging device 1 is diagrammatically shown. The apparatus 1 comprises a set of main magnetic coils 2 for generating a stationary and homogeneous main magnetic field and three sets of gradient coils 3, 4 and 5 for superimposing additional magnetic fields with controllable strength and having a gradient in a selected direction. Conventionally, the direction of the main magnetic field is labelled the z-direction, the two directions perpendicular thereto the x- and y-directions. The gradient coils are energized via a power supply 11. The apparatus 1 further comprises a radiation emitter 6, an antenna or coil, for emitting radio frequency (RF) pulses to a body 7, the radiation emitter 6 being coupled to a modulator 8 for generating and modulating the RF pulses. Also provided is a receiver for receiving the MR-signals, the receiver can be identical to the emitter 6 or be separate. If the emitter and receiver are physically the same antenna or coil as shown in Fig.2, a send-receive switch 9 is arranged to separate the received signals from the pulses to be emitted. The received MR-signals are input to a demodulator 10. The modulator 8, the emitter 6 and the power supply 11 for the gradient coils 3, 4 and 5 are controlled by a control system 12 to generate the above-described sequence of RF pulses and a corresponding sequence of magnetic field gradient pulses. The control system is usually a

microcomputer with a memory and a program control. For the practical implementation of the invention it comprises a programming with a description of an imaging procedure according to the above-described method. The demodulator 10 is coupled to a data processing unit 14, for example a computer, for transformation of the received echo signals into an image that can be made visible, for example on a visual display unit 15. There is an input means 16, e.g. an appropriate keyboard, connected to the control system 12, which enables an operator of the device to interactively adjust the parameters of the imaging procedure.

CLAIMS:

1. Method for magnetic resonance imaging of at least a portion of a body placed in a stationary and substantially homogeneous main magnetic field, the method comprising the following steps:

a) subjecting said portion to a T_2-preparation sequence;

b) further subjecting said portion to a 2D navigator sequence;

c) measuring a MR navigator signal;

d) generating a series of MR imaging signals by subjecting said portion to an imaging sequence (TFE);

e) measuring said MR imaging signals for reconstructing an MR image from said signals;

characterized in that

prior to subjecting said portion to said 2D navigator sequence in step b), said portion is further subjected to a 2D navigator restore sequence.

2. Method of claim 1, characterized in that said T_2-preparation sequence comprises at least two RF pulses (α_X), which are separated by a relaxation period, for enhancing the contrast between tissues with different transverse relaxation times.

3. Method of claim 1, characterized in that said 2D navigator sequence comprises at least one shaped RF pulse and at least one gradient pulse being switched during irradiation of said shaped RF pulse in order to excite nuclear magnetization within a spatially restricted navigator volume.

4. Method according to claims 2 and 3, characterized in that said 2D navigator restore sequence is applied during said relaxation period in order to selectively transform transverse magnetization within said navigator volume into longitudinal magnetization.

5. Method of claim 2, characterized in that said T_2-preparation sequence further comprises an even number of substantially 180° RF pulses.

6. Method of claim 1, characterized in that said MR navigator signal is employed for gating of said imaging sequence and/or for adjusting the parameters of said imaging sequence and/or for correction of said MR image.

7. Method of claim 1, characterized in that said imaging sequence is a turbo field echo sequence.

8. Device for magnetic resonance imaging of a body placed in a stationary and substantially homogeneous main magnetic field, the device comprising means for establishing said main magnetic field, means for generating magnetic field gradients superimposed upon said main magnetic field, means for radiating RF pulses towards said body, control means for controlling the generation of said magnetic field gradients and said RF pulses, means for receiving and sampling magnetic resonance signals generated by sequences of RF pulses and switched magnetic field gradients, and reconstruction means for forming an image from said signal samples, characterized in that said control means comprises a programming with a description of an imaging procedure according to the method of claim 1.

9. Device of claim 8, characterized in that it comprises ECG-means for registering ECG-data from said body, said ECG-data being processed by said control means for gating said imaging procedure.

10. A computer program comprising instructions to:

a) subject a portion of an object to be examined to a T_2-preparation sequence;

b) further subject said portion to a 2D navigator sequence;

c) measure a MR navigator signal;

d) generate a series of MR imaging signals by subjecting said portion to an imaging sequence;

e) measure said MR imaging signals for reconstructing an MR image from said signals;

characterized in that the computer program further has instructions to prior to subjecting said

portion to said 2D navigator sequence in step b), subject said portion is further to a 2D navigator restore sequence.

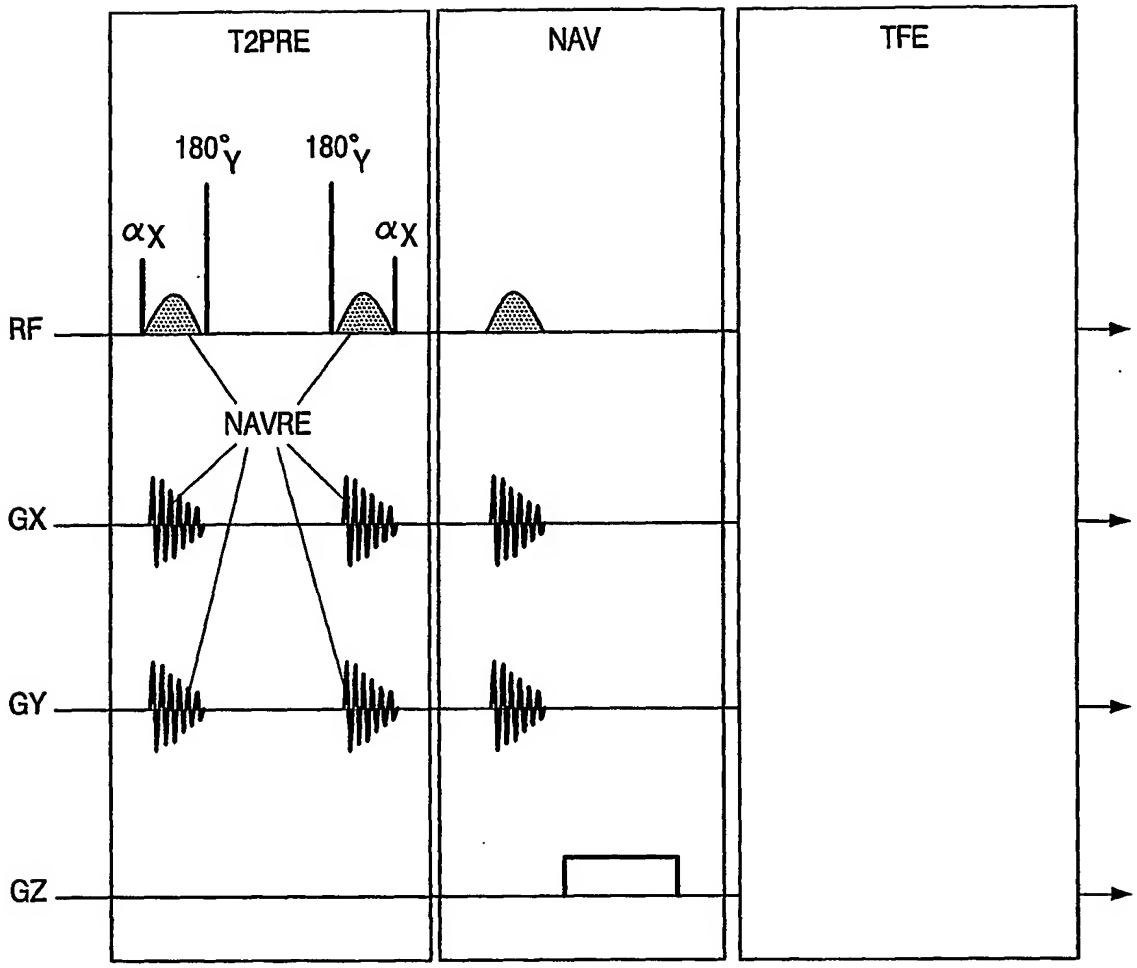

FIG. 1

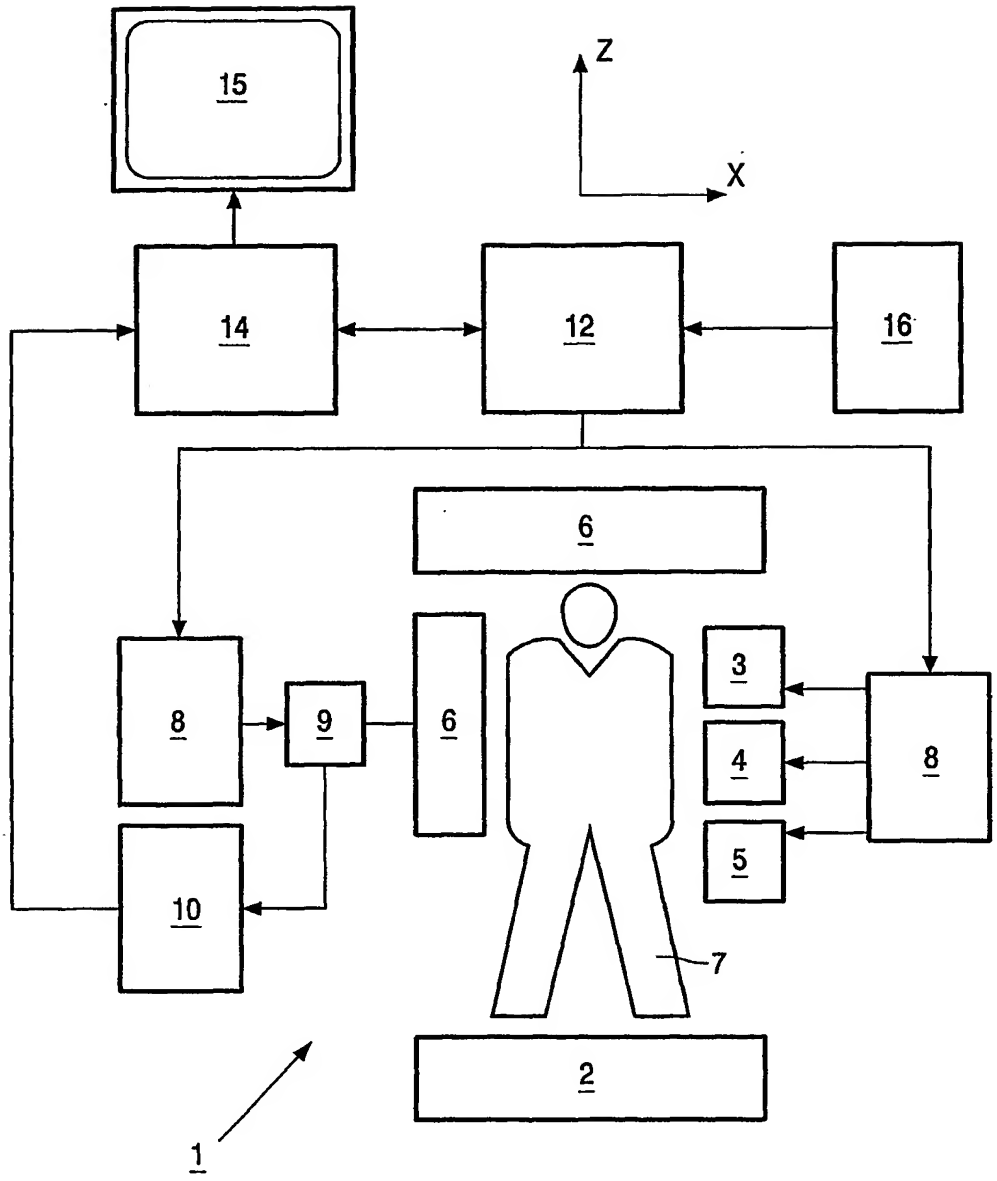

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 03/04024

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01R33/567

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
WPI Data, INSPEC, PAJ, MEDLINE, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	M. STUBER ET AL: "Three-dimensional high-resolution fast spin-echo coronary magnetic resonance angiography." MAGNETIC RESONANCE IN MEDICINE, vol. 45, February 2001 (2001-02), pages 206-211, XP002266074 ISSN: 0740-3194 cited in the application pages 206 - 208: "Methods", Fig. 1 --- -/--	1-6,8-10

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 January 2004	15/01/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Volmer, W

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	E. SPUENTRUP ET AL: "Navigator-gated and real-time motion corrected free-breathing MR Imaging of myocardial late enhancement." ROFO. FORTSCHRITTE AUF DEM GEBIETE DER RONTGENSTRAHLEN UND DER NEUEN BILDGEBENDEN VERFAHREN, vol. 174, May 2002 (2002-05), pages 562-567, XP008026029 ISSN: 1438-9029 pages 563, 564: "Introduction", "Methods" page: 566: "Discussion" fig. 1 ---	1,3,6-8, 10
X	R.M. BOTNAR ET AL: "3D coronary vessel wall imaging utilizing a local inversion technique with spiral image acquisition" MAGNETIC RESONANCE IN MEDICINE, vol. 46, 2001, pages 848-854, XP002266075 ISSN: 0740-3194 pages 848 - 851: "Methods", Figs. 1 -3 ---	1-6,8-10
A	M. STUBER ET AL: "Submillimeter three-dimensional coronary MR angiography with real-time navigator correction: comparison of navigator locations" RADIOLOGY, vol. 212, August 1999 (1999-08), pages 579-587, XP002266076 ISSN: 0033-8419 the whole document ---	1-10
X	EP 0 909 958 A (HITACHI MEDICAL CORP) 21 April 1999 (1999-04-21) the whole document -----	1,8,10

INTERNATIONAL SEARCH REPORT

International Application No
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0909958 A	21-04-1999	JP 11113878 A	27-04-1999
		CN 1216242 A	12-05-1999
		EP 0909958 A2	21-04-1999
		US 6118273 A	12-09-2000